

APPENDIX C

SHEAR WAVE VELOCITY INVESTIGATION



**NEWBY ISLAND SANITARY LANDFILL
BORINGS RB-10VA AND RB-12V
SUSPENSION P & S VELOCITIES**

**August 2, 2005
Report 5436-02**

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INTRODUCTION

OYO suspension velocity measurements were performed in two land borings adjacent to the Newby Island Sanitary Landfill near San Jose, California, as a component of the evaluation of the dynamic stability of the landfill. Suspension logging data acquisition was performed on July 13 and 14, 2005 by Rob Steller of GEOVision. The work was performed under subcontract with GeoLogic Associates, with Robbie Warner as the point of contact for GeoLogic.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of suspension velocity measurements collected on July 13 and 14, 2005, in the uncased borings designated RB-10VA and RB-12V, as detailed below. The purpose of these studies was to supplement stratigraphic information obtained during GeoLogic's soil sampling program and to acquire shear wave velocities and compressional wave velocities as a function of depth, which, in turn, can be used to characterize ground response to earthquake motion.

BORING DESIGNATION	DATE LOGGED	PERIMETER LEVEE CENTERLINE STATION	COORDINATES (+/- 10 FT)	
			NORTHING	EASTING
RB-10VA	7/14/05	30+00	+/-351450	+/-1582420
RB-12V	7/13/05	125+00	+/-354270	+/-1582000

Table 1. Boring locations and logging dates

The OYO Model 170 Suspension Logging Recorder and Suspension Logging Probe were used to obtain in-situ horizontal shear and compressional wave velocity measurements at 1.64 ft intervals. The acquired data was analyzed and a profile of velocity versus depth was produced for both compressional and horizontally polarized shear waves.

A detailed reference for the velocity measurement techniques used in this study is:

Guidelines for Determining Design Basis Ground Motions, Report TR-102293,
Electric Power Research Institute, Palo Alto, California, November 1993,
Sections 7 and 8.

SUSPENSION INSTRUMENTATION

Suspension soil velocity measurements were performed using the Model 170 Suspension Logging system, manufactured by OYO Corporation. This system directly determines the average velocity of a 3.28 ft high segment of the soil column surrounding the boring of interest by measuring the elapsed time between arrivals of a wave propagating upward through the soil column. The receivers that detect the wave, and the source that generates the wave, are moved as a unit in the boring producing relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal shear-wave source (S_H) and compressional-wave source (P), joined to two biaxial receivers by a flexible isolation cylinder, as shown in Figure 1. The separation of the two receivers is 3.28 ft, allowing average wave velocity in the region between the receivers to be determined by inversion of the wave travel time between the two receivers. The total length of the probe as used in this survey is 22 ft, with the center point of the receiver pair 15.4 ft above the bottom end of the probe. The probe receives control signals from, and sends the amplified receiver signals to, instrumentation on the surface via an armored 7 conductor cable. The cable is wound onto the drum of a winch and is used to support the probe. Cable travel is measured to provide probe depth data.

The entire probe is suspended by the cable and centered in the boring by nylon "whiskers", therefore, source motion is not coupled directly to the boring walls; rather, the source motion creates a horizontally propagating impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure wave is converted to P and S_H -waves in the surrounding soil and rock as it impinges upon the boring wall. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil waves pass their location. Separation of the P and S_H -waves at the receivers is performed using the following steps:

1. Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S_H -wave signals.
2. At each depth, S_H -wave signals are recorded with the source actuated in opposite directions, producing S_H -wave signals of opposite polarity, providing a characteristic S_H -wave signature distinct from the P-wave signal.
3. The 10.3 ft separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S_H -wave signal arrives at the receiver. In faster soils or rock, the isolation cylinder is extended to allow greater separation of the P- and S_H -wave signals.
4. In saturated soils, the received P-wave signal is typically of much higher frequency than the received S_H -wave signal, permitting additional separation of the two signals by low pass filtering.
5. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe (foot versus inch scale), preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S_H -wave arrivals; reversal of the source changes the polarity of the S_H -wave pattern but not the P-wave pattern.

The data from each receiver during each source activation is recorded as a different channel on the recording system. The Model 170 has six channels (two simultaneous recording channels), each with a 12 bit 1024 sample record. The recorded data is displayed on a CRT display and on paper tape output as six channels with a common time scale. Data is stored on 3.5 inch floppy diskettes for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the CRT or paper tape allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Model 170 digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix B.

SUSPENSION MEASUREMENT PROCEDURES

Both borings were logged uncased, filled with polymer based drilling fluid. The boring probe was positioned with the mid-point of the receiver spacing at grade, and the mechanical and electronic depth counters were set to zero. The probe was lowered to the bottom of the boring, stopping at 1.64 ft intervals to collect data, as summarized below.

At each measurement depth the measurement sequence of two opposite horizontal records and one vertical record was performed, and the gains were adjusted as required. The data from each depth was printed on paper tape, checked, and recorded on diskette before moving to the next depth.

Upon completion of the measurements, the probe zero depth indication at grade was verified prior to removal from the boring.

BORING NUMBER	RUN NUMBER	DEPTH RANGE (FEET)	DEPTH AS DRILLED (FEET)	LOST TO SLOUGH/COLLAPSE (FEET)	SAMPLE INTERVAL (FEET)	DATE LOGGED
RB-10VA	1	23.0 – 103.4	120	1.2	1.64	7/14/05
RB-12V	1	27.9 – 111.5	130	3.1	1.64	7/13/05

Table 2. Logging dates and depth ranges

SUSPENSION DATA ANALYSIS

The recorded digital waveforms were analyzed to locate the first minima on the vertical axis records, indicating the arrival of P-wave energy. The difference in travel time between receiver 1 and receiver 2 (R1-R2) arrivals was used to calculate the P-wave velocity for that 3.28 ft segment of the soil column. When observable, P-wave arrivals on the horizontal axis records were used to verify the velocities determined from the vertical axis data.

The P-wave velocity calculated from the travel time over the 10.3 ft interval from source to receiver 1 (S-R1) was calculated and plotted for quality assurance of the velocity derived from the travel time between receivers. In this analysis, the depth values as recorded were increased by 6.79 ft to correspond to the mid-point of the 10.3 ft S-R1 interval, as illustrated in Figure 1. Travel times were obtained by picking the first break of the P-wave signal at receiver 1 and subtracting 3.85 milliseconds, the calculated and experimentally verified delay from source trigger pulse (beginning of record) to source impact. This delay corresponds to the duration of acceleration of the solenoid before impact.

The recorded digital records were studied to establish the presence of clear S_H -wave pulses, as indicated by the presence of opposite polarity pulses on each pair of horizontal records. Ideally, the S_H -wave signals from the 'normal' and 'reverse' source pulses are very nearly inverted images of each other. Digital FFT - IFFT lowpass filtering was used to remove the higher frequency P-wave signal from the S_H -wave signal. Different filter cutoffs were used to separate P- and S_H -waves at different depths, ranging from 500 Hz in the slowest zones to 2000 Hz in the regions of highest velocity. At each depth, the filter frequency was selected to be at least twice the fundamental frequency of the S_H -wave signal being filtered.

Generally, the first maxima was picked for the 'normal' signals and the first minima for the 'reverse' signals, although other points on the waveform were used if the first pulse was distorted. The absolute arrival time of the 'normal' and 'reverse' signals may vary by +/- 0.2 milliseconds, due to differences in the actuation time of the solenoid source caused by constant mechanical bias in the source or by boring inclination. This variation does not affect the R1-R2 velocity determinations, as the differential time is measured between arrivals of waves created by the same source actuation. The final velocity value is the average of the values obtained from the 'normal' and 'reverse' source actuations.

As with the P-wave data, S_H -wave velocity calculated from the travel time over the 10.3 ft interval from source to receiver 1 was calculated and plotted for verification of the velocity derived from the travel time between receivers. In this analysis, the depth values were increased by 6.79 ft to correspond to the mid-point of the 10.3 ft S-R1 interval. Travel times were obtained by picking the first break of the S_H -wave signal at the near receiver and subtracting 3.85 milliseconds, the calculated and experimentally verified delay from the beginning of the record at the source trigger pulse to source impact.

Figure 2 shows an example of R1 - R2 measurements on a sample filtered suspension record. In Figure 2, the time difference over the 3.28 ft interval of 1.88 milliseconds for the horizontal signals is equivalent to an S_H -wave velocity of 1745 ft/sec. Whenever possible, time differences were determined from several phase points on the S_H -waveform records to verify the data obtained from the first arrival of the S_H -wave pulse. Figure 3 displays the same record before filtering of the S_H -waveform record with an 1400 Hz FFT - IFFT digital lowpass filter, illustrating the presence of higher frequency P-wave energy at the beginning of the record, and distortion of the lower frequency S_H -wave by residual P-wave signal.

SUSPENSION RESULTS

Suspension R1-R2 P- and S_H-wave velocities from RB-10VA and RB-12V are plotted in Figures 4 and 6, respectively. S_H-wave velocities are plotted at expanded scale in Figures 5 and 7. The suspension velocity data shown in these figures are presented in Tables 3 and 4. P- and S_H-wave velocity data from R1-R2 analysis and quality assurance analysis of S-R1 data are plotted together in Figures A1 and A2 to aid in visual comparison. It must be noted that R1-R2 data is an average velocity over a 3.28 ft segment of the soil column; S-R1 data is an average over 10.3 ft, creating a significant smoothing relative to the R1-R2 plots. S-R1 data are presented in Tables A1 and A2. Good correspondence between the shape of the P- and S_H-wave velocity curves is observed for both these data sets. The velocities derived from S-R1 and R1-R2 data are in excellent agreement, providing verification of the higher resolution R1-R2 data.

Calibration procedures and records for the suspension measurement system are presented in Appendix B.

SUMMARY

Discussion of Suspension Results

Both P- and S_H-wave velocities were measured using the OYO Suspension Method in two uncased land borings at depths up to 111.5 ft below grade at Newby Island Sanitary Landfill near San Jose, California. Both borings were located in an industrial environment, but no significant signal contamination from cultural vibration was observed.

Both borings show a P-wave velocity below that of water (5000 ft/sec) at a depth of approximately 35 ft, despite the fact that this depth is well below the static water table. This is caused by gas bubbles trapped in the sediments resulting from organic decomposition, and is a signature seen in young bay muds throughout the San Francisco Bay.

Quality Assurance

These velocity measurements were performed using industry-standard or better methods for both measurements and analyses. All work was performed under GEOVision quality assurance procedures, which include:

- Use of NIST-traceable calibrations, where applicable, for field and laboratory instrumentation
- Use of standard field data logs
- Use of independent verification of data by comparison of receiver-to-receiver and source-to-receiver velocities
- Independent review of calculations and results by a registered professional engineer, geologist, or geophysicist.

Data Reliability

P- and S_H-wave velocity measurement using the Suspension Method gives average velocities over a 3.28 ft interval of depth. This high resolution results in the scatter of values shown in the graphs. Individual measurements are very reliable with estimated precision of +/- 5%. Standardized field procedures and quality assurance checks add to the reliability of these data.

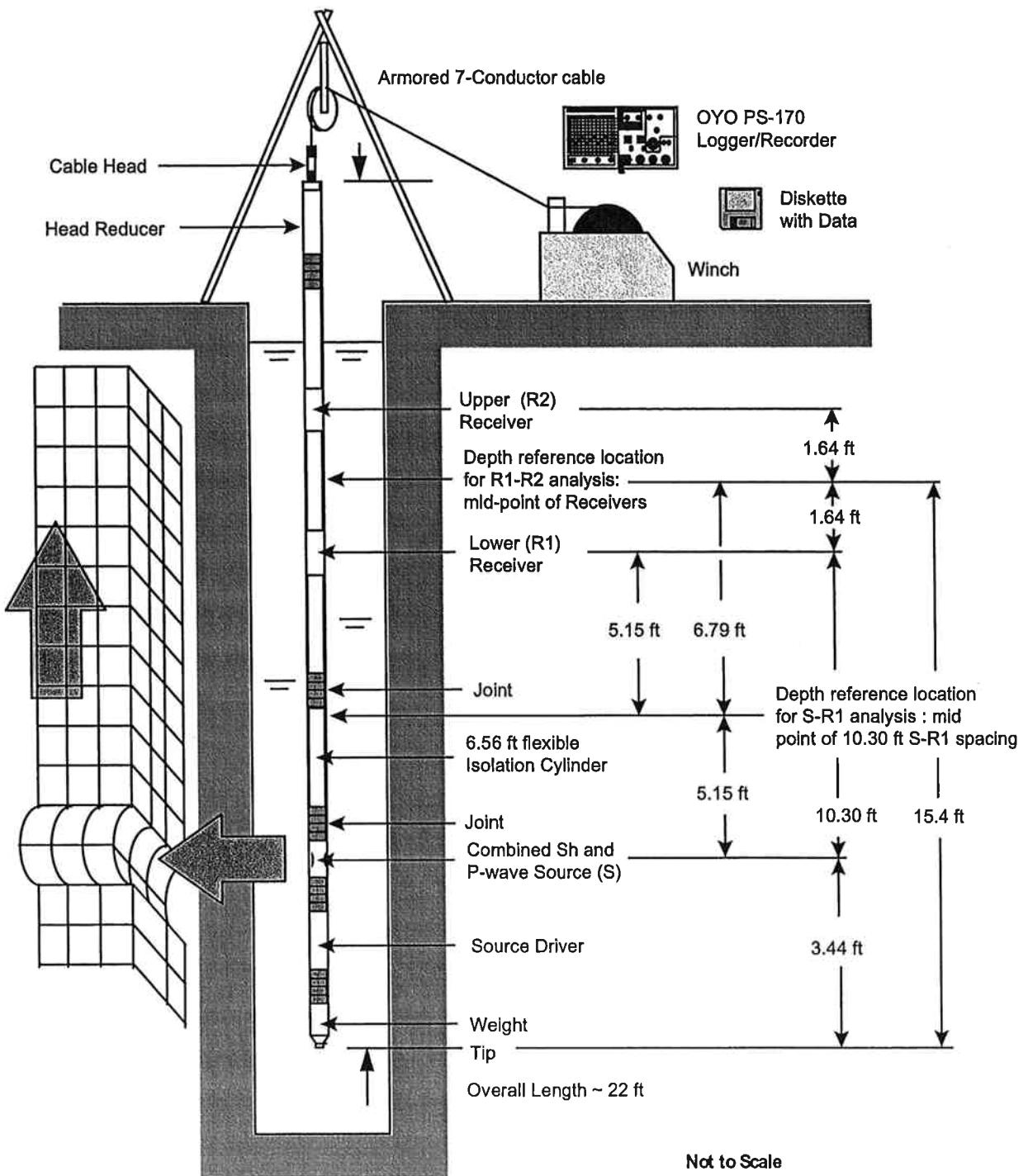


Figure 1. Concept illustration of P-S logging system

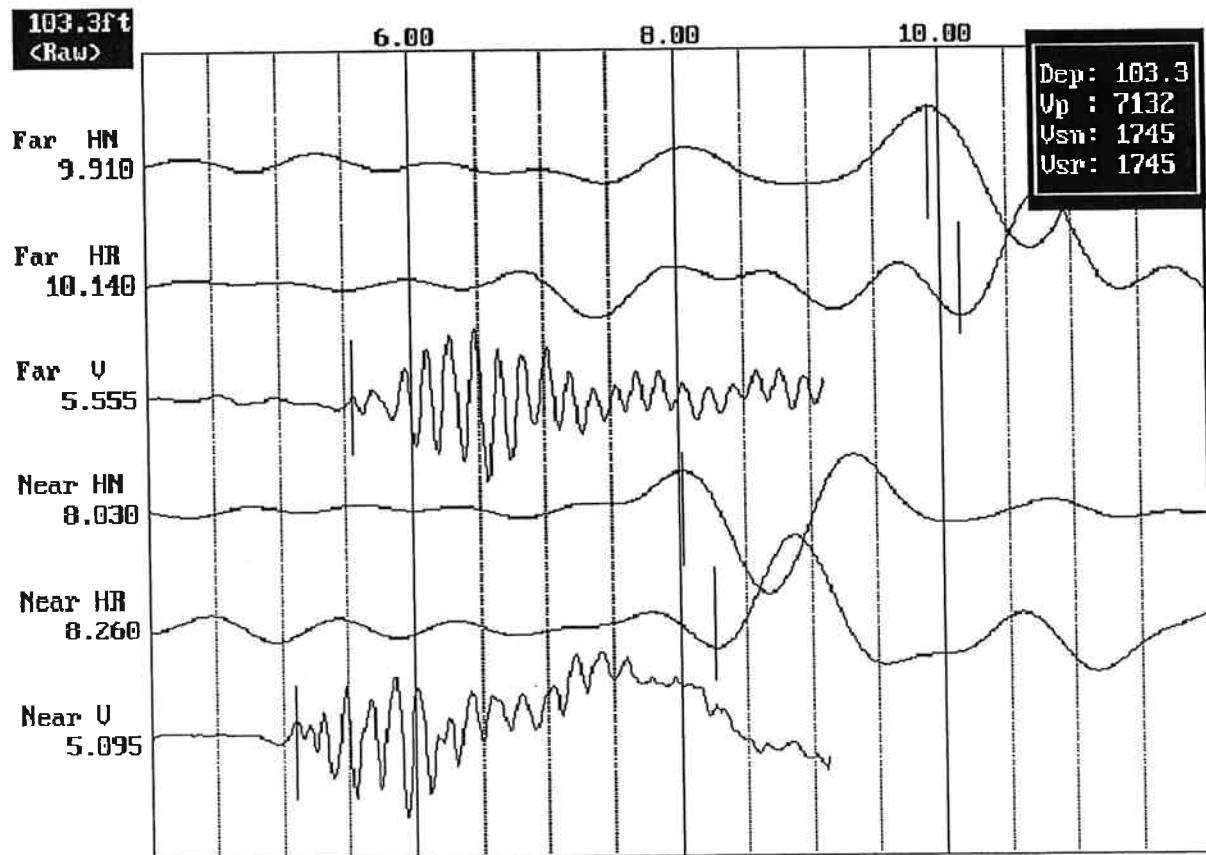


Figure 2. Example of filtered (1400 Hz lowpass) record

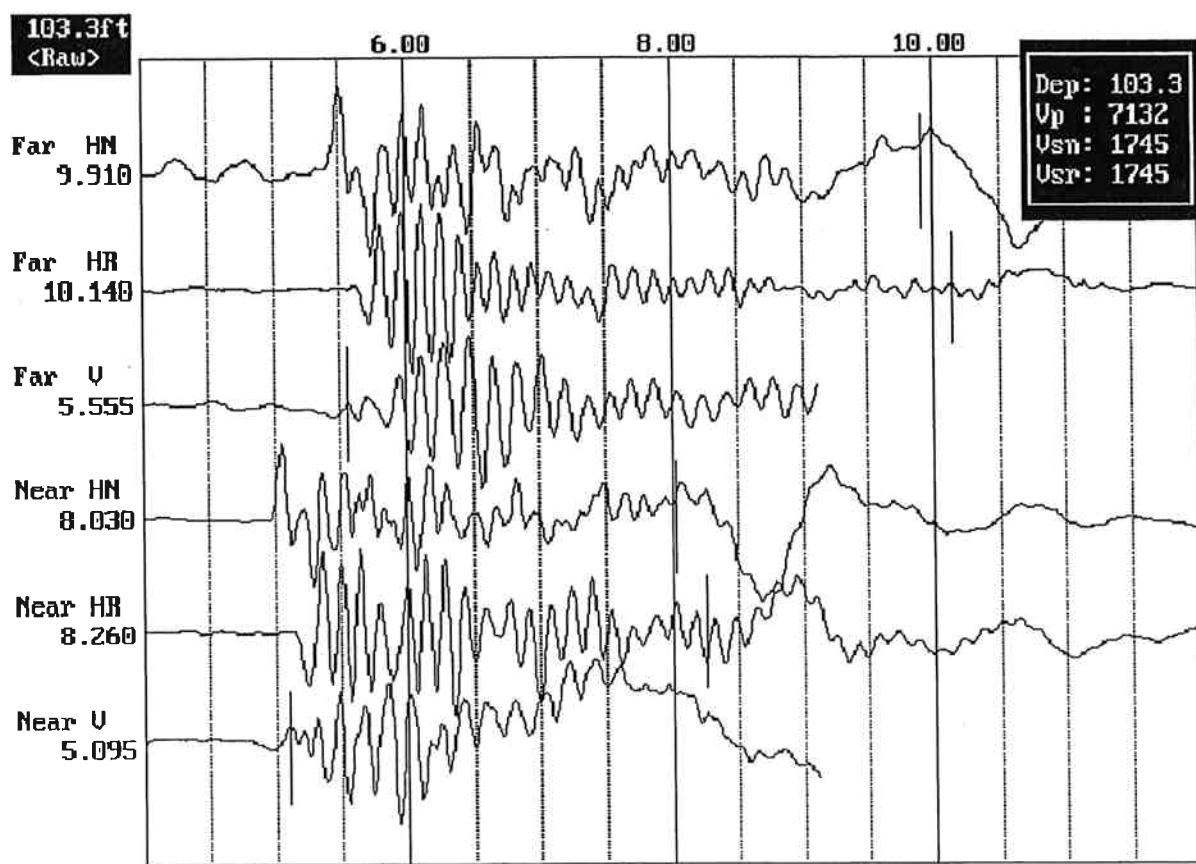


Figure 3. Example of unfiltered record

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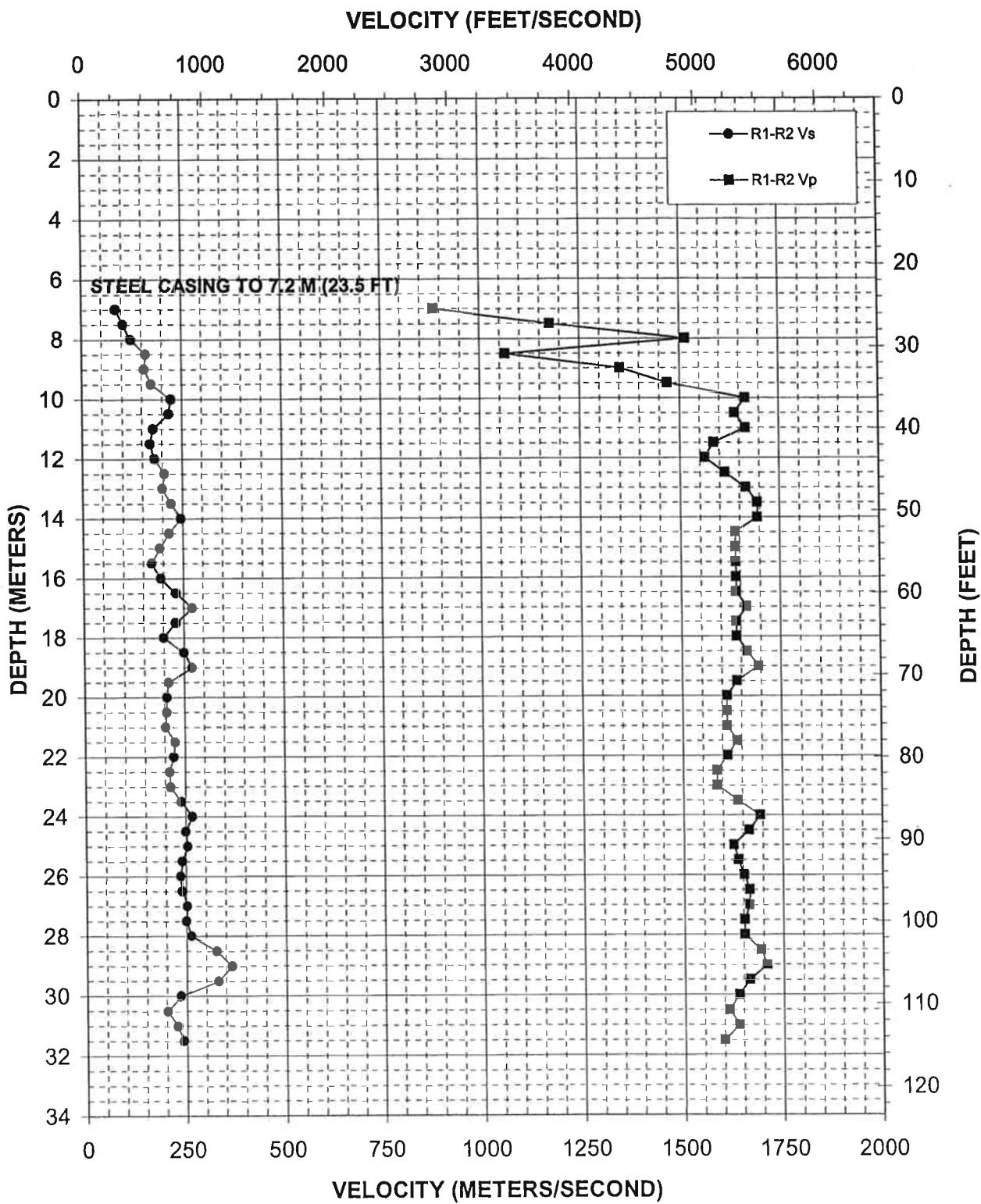


Figure 4. Boring RB-10VA, Suspension P- and S_H -wave velocities

NEWBY ISLAND SANITARY LANDFILL BORING RB-10VA

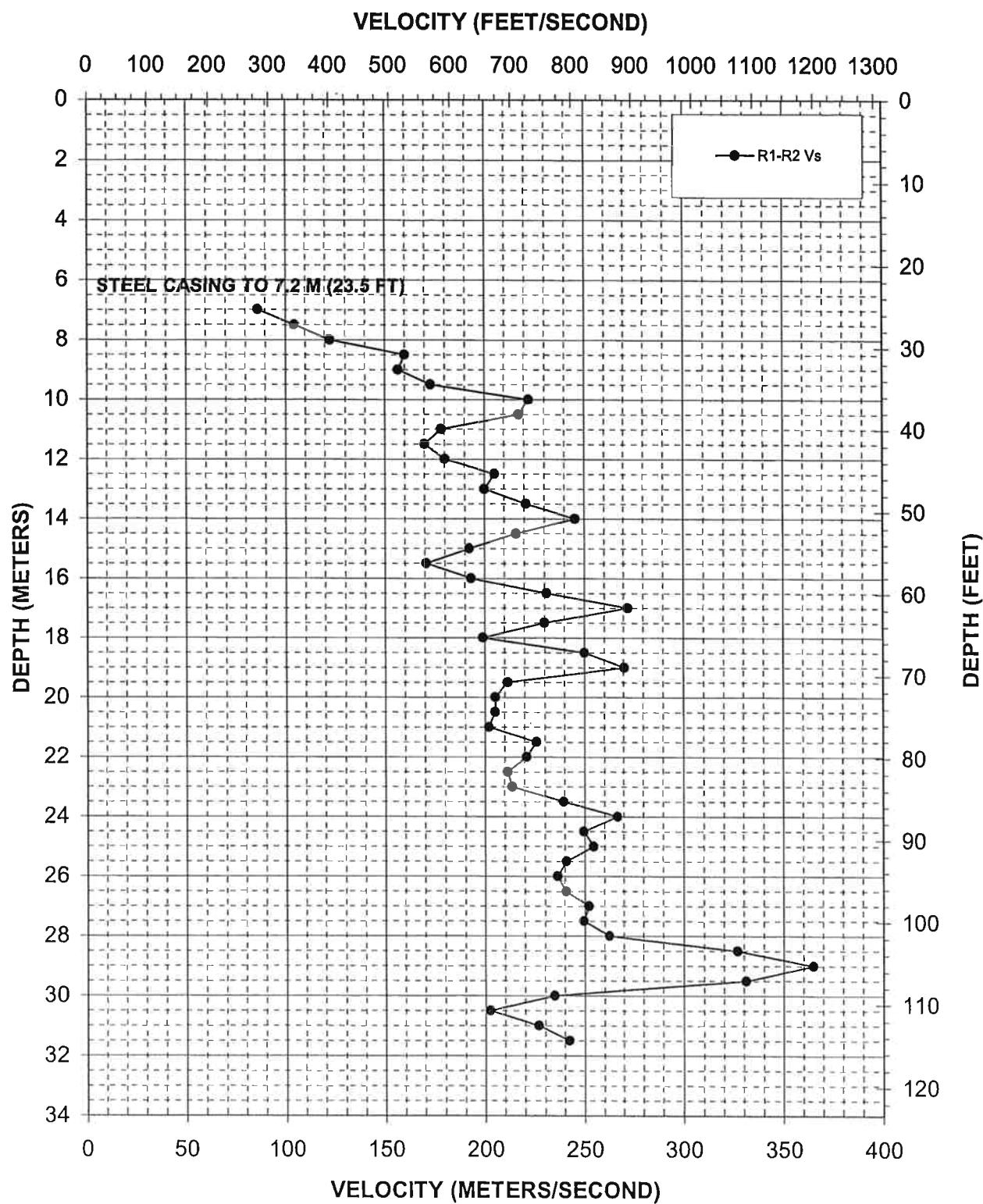


Figure 5. Boring RB-10VA, Suspension S_H -wave velocities

Depth		Pick Times					Velocity				
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	V-S _H (m/sec)	V-P (m/sec)	V-S _H (ft/sec)	V-P (ft/sec)
7.0	23.0	32.90	32.30	7.51	21.80	20.20	6.38	86	885	283	2903
7.5	24.6	30.90	31.60	7.22	21.30	22.10	6.37	105	1176	344	3860
8.0	26.2	29.70	29.90	7.04	21.70	21.60	6.38	123	1515	403	4971
8.5	27.9	27.60	27.25	7.14	20.95	21.40	6.20	160	1064	525	3490
9.0	29.5	26.55	26.65	7.04	20.40	20.05	6.30	157	1351	515	4434
9.5	31.2	26.20	26.10	6.68	20.35	20.40	6.00	173	1471	568	4825
10.0	32.8	25.50	25.30	6.58	20.85	20.95	5.98	222	1667	729	5468
10.5	34.4	25.10	25.00	6.65	20.60	20.30	6.04	217	1639	713	5378
11.0	36.1	25.85	25.85	8.71	20.20	20.30	6.11	179	1667	586	5468
11.5	37.7	25.50	25.55	6.72	19.70	19.60	6.09	170	1587	558	5208
12.0	39.4	25.25	25.35	6.67	19.75	19.75	6.03	180	1563	591	5126
12.5	41.0	24.45	24.55	6.66	19.60	19.65	6.04	205	1613	673	5292
13.0	42.7	24.05	24.10	6.64	19.00	19.15	6.04	200	1667	656	5468
13.5	44.3	23.90	23.85	6.63	19.35	19.35	6.04	221	1695	725	5561
14.0	45.9	23.75	23.70	6.61	19.65	19.65	6.02	245	1695	805	5561
14.5	47.6	24.45	24.45	6.63	19.85	19.80	6.02	216	1639	709	5378
15.0	49.2	23.80	23.70	6.62	18.55	18.55	6.01	192	1639	631	5378
15.5	50.9	23.90	23.65	6.60	17.90	17.95	5.99	171	1639	561	5378
16.0	52.5	23.60	23.55	6.57	18.40	18.40	5.96	193	1639	634	5378
16.5	54.1	23.05	23.00	6.56	18.70	18.70	5.95	231	1639	759	5378
17.0	55.8	23.05	23.10	6.56	19.40	19.40	5.96	272	1667	893	5468
17.5	57.4	23.30	23.25	6.57	18.90	18.95	5.96	230	1639	754	5378
18.0	59.1	23.40	23.40	6.57	18.35	18.40	5.96	199	1639	653	5378
18.5	60.7	23.00	23.00	6.57	18.95	19.05	5.97	250	1667	820	5468
19.0	62.3	22.80	22.85	6.57	19.10	19.15	5.98	270	1695	887	5561
19.5	64.0	23.60	23.60	6.59	18.85	18.90	5.98	212	1639	694	5378
20.0	65.6	23.50	23.45	6.61	18.60	18.60	5.99	205	1613	673	5292
20.5	67.3	22.65	22.65	6.59	17.75	17.80	5.97	205	1613	673	5292
21.0	68.9	22.50	22.50	6.58	17.55	17.55	5.96	202	1613	663	5292
21.5	70.5	21.90	21.90	6.55	17.45	17.50	5.94	226	1639	741	5378
22.0	72.2	21.75	21.80	6.54	17.25	17.25	5.92	221	1613	725	5292
22.5	73.8	21.65	21.65	6.56	16.90	16.95	5.93	212	1587	694	5208
23.0	75.5	21.35	21.35	6.53	16.65	16.70	5.90	214	1587	702	5208
23.5	77.1	20.90	20.90	6.52	16.70	16.75	5.91	240	1639	786	5378
24.0	78.7	20.65	20.65	6.50	16.90	16.90	5.91	267	1695	875	5561
24.5	80.4	20.64	20.64	6.52	16.62	16.64	5.92	249	1667	818	5468
25.0	82.0	20.30	20.26	6.54	16.34	16.36	5.92	254	1626	835	5335
25.5	83.7	19.92	19.90	6.53	15.76	15.76	5.92	241	1639	791	5378
26.0	85.3	20.08	20.14	6.50	15.86	15.90	5.89	236	1653	776	5423
26.5	86.9	20.70	20.60	6.51	16.52	16.48	5.91	241	1667	791	5468
27.0	88.6	20.46	20.48	6.50	16.50	16.50	5.90	252	1667	826	5468
27.5	90.2	20.12	20.12	6.52	16.10	16.12	5.92	249	1653	818	5423
28.0	91.9	20.04	20.02	6.53	16.20	16.24	5.92	262	1653	861	5423
28.5	93.5	19.88	19.88	6.52	16.80	16.84	5.93	327	1695	1072	5561
29.0	95.1	20.02	20.00	6.53	17.26	17.28	5.95	365	1709	1197	5608
29.5	96.8	20.52	20.52	6.54	17.48	17.52	5.94	331	1667	1086	5468
30.0	98.4	20.84	20.88	6.56	16.58	16.62	5.95	235	1639	770	5378
30.5	100.1	21.22	21.22	6.55	16.28	16.28	5.93	202	1613	664	5292
31.0	101.7	20.50	20.52	6.54	16.08	16.12	5.93	227	1639	744	5378
31.5	103.3	20.24	20.26	6.54	16.10	16.14	5.91	242	1600	794	5249

Table 3. Boring RB-10VA, Suspension R1-R2 depth, pick times, and velocities

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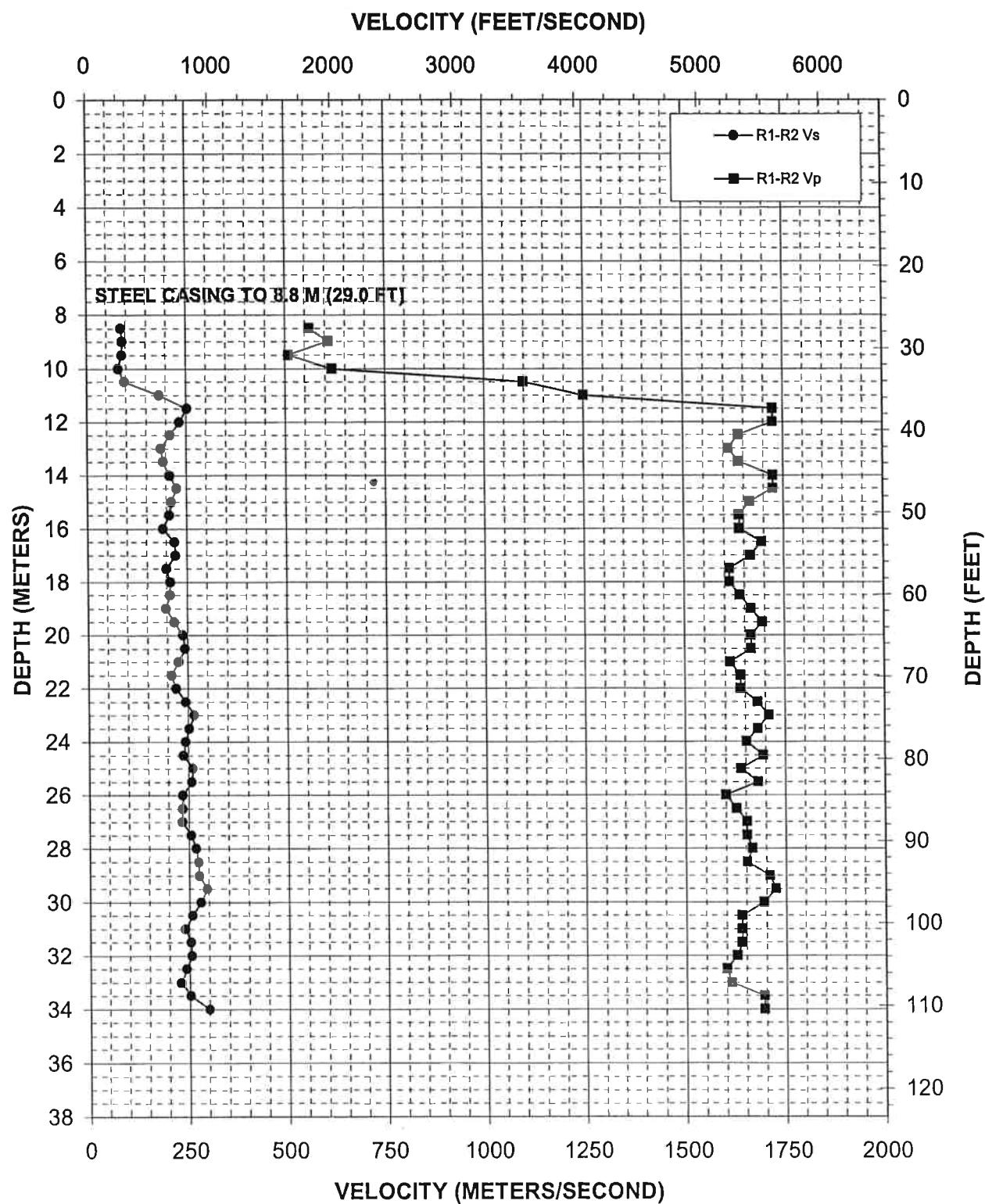


Figure 6. Boring RB-12V, Suspension P- and S_H -wave velocities

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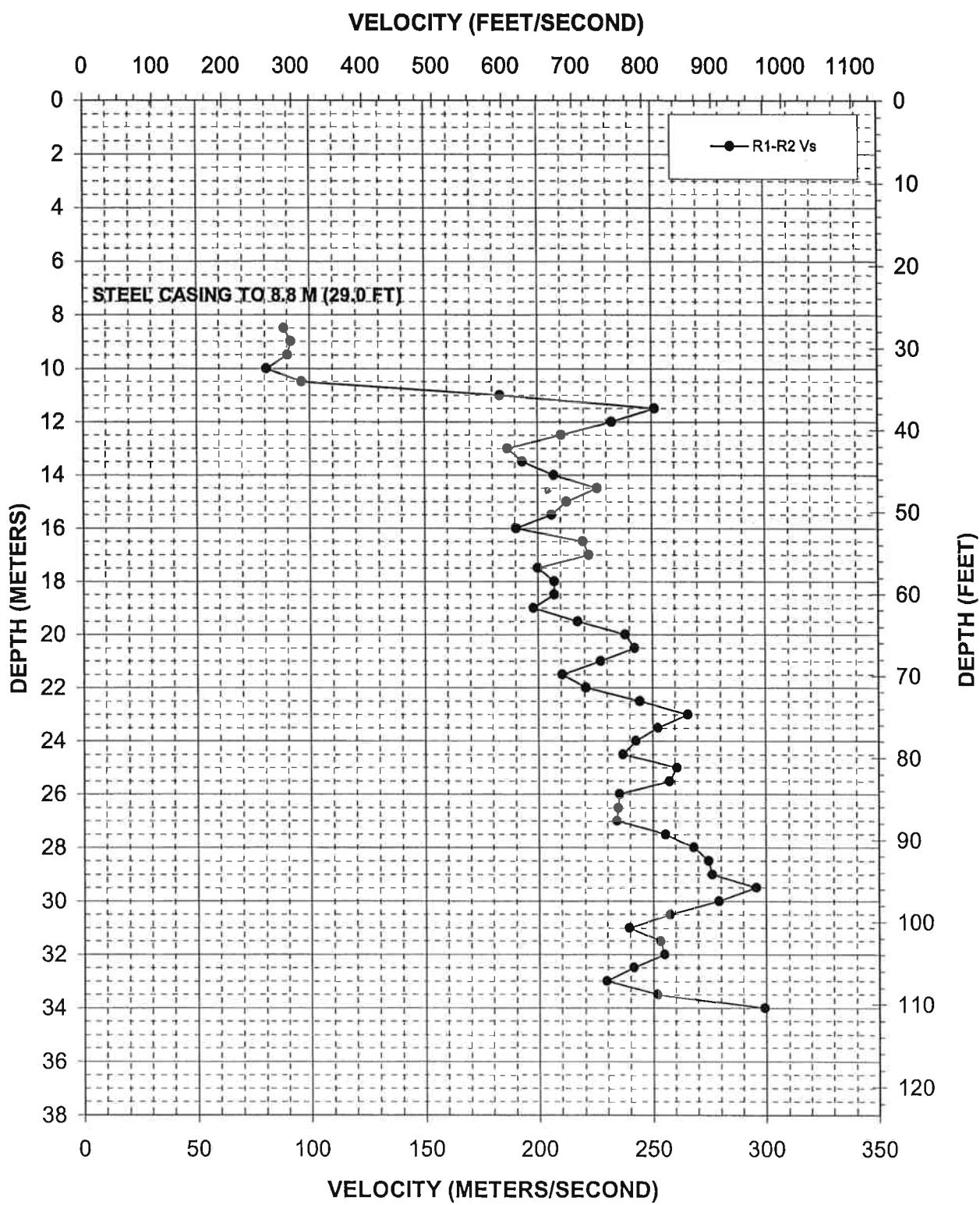


Figure 7. Boring RB-12V, Suspension S_H -wave velocities

Depth		Pick Times						Velocity			
(m)	(feet)	Far-Hn (millisec)	Far-Hr (millisec)	Far-V (millisec)	Near-Hn (millisec)	Near-Hr (millisec)	Near-V (millisec)	V-S _H (m/sec)	V-P (m/sec)	V-S _H (ft/sec)	V-P (ft/sec)
8.5	27.9	39.90	39.50	10.80	28.60	28.30	9.02	89	562	292	1843
9.0	29.5	37.50	37.20	9.14	26.60	26.30	7.50	92	610	301	2001
9.5	31.2	33.80	33.80	9.89	22.45	23.00	7.93	90	510	296	1674
10.0	32.8	31.90	31.20	7.67	19.20	19.15	6.05	81	617	265	2025
10.5	34.4	28.40	28.75	6.80	18.25	18.20	5.89	97	1099	317	3605
11.0	36.1	24.30	24.20	6.69	18.75	18.85	5.89	183	1250	602	4101
11.5	37.7	23.35	23.05	6.48	19.10	19.35	5.90	252	1724	825	5657
12.0	39.4	24.15	24.30	6.49	19.90	19.95	5.91	233	1724	763	5657
12.5	41.0	24.45	24.35	6.50	19.65	19.65	5.89	211	1639	691	5378
13.0	42.7	24.40	24.35	6.51	19.00	19.05	5.89	187	1613	613	5292
13.5	44.3	23.75	23.75	6.49	18.50	18.65	5.88	193	1639	634	5378
14.0	45.9	23.70	23.65	6.49	18.85	18.85	5.91	207	1724	680	5657
14.5	47.6	23.40	23.30	6.49	18.90	18.95	5.91	226	1724	741	5657
15.0	49.2	23.65	23.70	6.53	18.95	19.00	5.93	213	1667	698	5468
15.5	50.9	24.15	24.10	6.55	19.25	19.30	5.94	206	1639	676	5378
16.0	52.5	24.20	24.05	6.55	18.85	18.90	5.94	190	1639	625	5378
16.5	54.1	23.55	23.50	6.51	18.95	19.00	5.92	220	1695	721	5561
17.0	55.8	23.10	23.05	6.49	18.55	18.60	5.89	222	1667	729	5468
17.5	57.4	23.50	23.55	6.51	18.50	18.55	5.89	200	1613	656	5292
18.0	59.1	23.55	23.55	6.51	18.70	18.75	5.89	207	1613	680	5292
18.5	60.7	23.05	23.05	6.50	18.20	18.25	5.89	207	1639	680	5378
19.0	62.3	22.75	22.70	6.51	17.65	17.70	5.91	198	1667	650	5468
19.5	64.0	22.00	22.00	6.47	17.40	17.40	5.88	217	1695	713	5561
20.0	65.6	21.55	21.55	6.49	17.40	17.30	5.89	238	1667	781	5468
20.5	67.3	21.45	21.55	6.48	17.30	17.45	5.88	242	1667	795	5468
21.0	68.9	21.50	21.50	6.50	17.10	17.10	5.88	227	1613	746	5292
21.5	70.5	21.00	21.25	6.49	16.25	16.50	5.88	211	1639	691	5378
22.0	72.2	20.84	20.94	6.48	16.32	16.40	5.87	221	1639	724	5378
22.5	73.8	20.48	20.60	6.49	16.38	16.52	5.89	244	1681	802	5514
23.0	75.5	20.80	20.82	6.50	17.02	17.08	5.92	266	1709	873	5608
23.5	77.1	20.94	20.92	6.51	16.92	17.02	5.92	253	1681	828	5514
24.0	78.7	20.90	20.96	6.52	16.80	16.82	5.92	243	1653	796	5423
24.5	80.4	20.64	20.62	6.50	16.40	16.42	5.91	237	1695	777	5561
25.0	82.0	20.46	20.48	6.51	16.62	16.66	5.90	261	1639	857	5378
25.5	83.7	20.20	20.10	6.52	16.26	16.28	5.92	258	1681	846	5514
26.0	85.3	20.08	20.08	6.52	15.84	15.82	5.90	235	1600	772	5249
26.5	86.9	19.76	19.74	6.55	15.46	15.52	5.93	235	1626	770	5335
27.0	88.6	19.90	19.90	6.53	15.58	15.68	5.92	234	1653	768	5423
27.5	90.2	19.74	19.78	6.54	15.88	15.82	5.94	256	1653	839	5423
28.0	91.9	19.86	19.94	6.52	16.14	16.20	5.92	268	1667	880	5468
28.5	93.5	19.96	20.04	6.53	16.36	16.36	5.93	275	1653	901	5423
29.0	95.1	20.42	20.40	6.55	16.78	16.80	5.96	276	1709	906	5608
29.5	96.8	20.60	20.62	6.55	17.20	17.26	5.97	296	1724	971	5657
30.0	98.4	20.60	20.54	6.58	17.00	16.98	5.99	279	1695	916	5561
30.5	100.1	20.50	20.42	6.57	16.58	16.58	5.96	258	1639	846	5378
31.0	101.7	20.44	20.46	6.57	16.26	16.30	5.96	240	1639	787	5378
31.5	103.3	20.46	20.44	6.56	16.52	16.48	5.95	253	1639	831	5378
32.0	105.0	20.38	20.42	6.56	16.44	16.52	5.94	255	1626	837	5335
32.5	106.6	20.36	20.36	6.55	16.20	16.24	5.92	242	1600	792	5249
33.0	108.3	20.32	20.30	6.52	15.90	16.00	5.90	229	1613	752	5292
33.5	109.9	20.26	20.26	6.55	16.30	16.28	5.96	252	1695	826	5561
34.0	111.5	19.84	19.88	6.54	16.48	16.56	5.95	299	1695	982	5561

Table 4. Boring RB-12V, Suspension R1-R2 depth, pick times, and velocities

APPENDIX A

**SUSPENSION VELOCITY MEASUREMENT
QUALITY ASSURANCE SUSPENSION SOURCE
TO RECEIVER ANALYSIS RESULTS**

NEWBY ISLAND SANITARY LANDFILL BORING RB-10VA

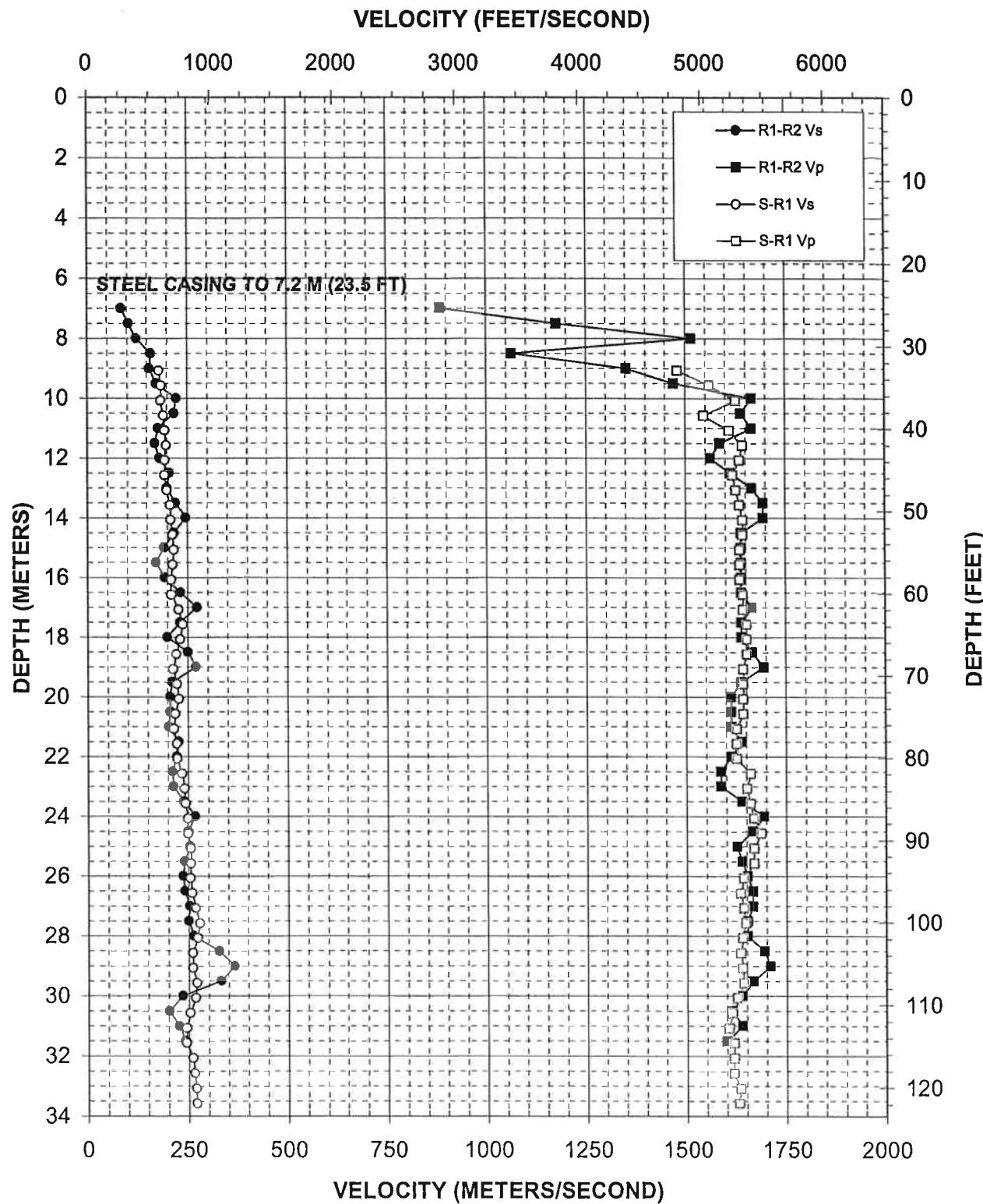


Figure A-1. Boring RB-10VA, R1 - R2 high resolution analysis
and S-R1 quality assurance analysis P- and S_H -wave data

Depth (meters)	Velocity		Depth (feet)	Velocity	
	V-S _H (m/sec)	V-p (m/sec)		V- S _H (ft/sec)	V-p (ft/sec)
9.1	181	1481	29.8	594	4859
9.6	186	1562	31.4	611	5125
10.1	184	1627	33.0	602	5338
10.6	192	1547	34.7	629	5075
11.1	196	1610	36.3	642	5283
11.6	199	1644	38.0	652	5394
12.1	194	1635	39.6	638	5366
12.6	194	1619	41.2	638	5310
13.1	200	1627	42.9	656	5338
13.6	208	1635	44.5	682	5366
14.1	208	1644	46.2	682	5394
14.6	212	1644	47.8	696	5394
15.1	216	1635	49.4	708	5366
15.6	212	1635	51.1	696	5366
16.1	209	1635	52.7	685	5366
16.6	210	1644	54.4	689	5394
17.1	228	1644	56.0	747	5394
17.6	237	1653	57.6	777	5422
18.1	231	1653	59.3	757	5422
18.6	221	1653	60.9	725	5422
19.1	214	1644	62.6	701	5394
19.6	222	1644	64.2	728	5394
20.1	227	1644	65.8	744	5394
20.6	218	1644	67.5	715	5394
21.1	215	1627	69.1	706	5338
21.6	221	1627	70.8	726	5338
22.1	222	1627	72.4	729	5338
22.6	235	1661	74.0	772	5451
23.1	241	1653	75.7	789	5422
23.6	242	1661	77.3	796	5451
24.1	248	1670	79.0	814	5480
24.6	250	1688	80.6	821	5539
25.1	256	1670	82.3	841	5480
25.6	256	1670	83.9	841	5480
26.1	254	1644	85.5	834	5394
26.6	259	1635	87.2	849	5366
27.1	268	1644	88.8	878	5394
27.6	279	1648	90.5	914	5408
28.1	272	1640	92.1	892	5380
28.6	260	1635	93.7	854	5366

Depth (meters)	Velocity		Depth (feet)	Velocity	
	V-S _H (m/sec)	V-p (m/sec)		V- S _H (ft/sec)	V-p (ft/sec)
29.1	260	1640	95.4	854	5380
29.6	270	1644	97.0	887	5394
30.1	266	1627	98.7	874	5338
30.6	253	1614	100.3	830	5297
31.1	245	1606	101.9	804	5269
31.6	244	1619	103.6	800	5310
32.1	260	1619	105.2	854	5310
32.6	265	1619	106.9	869	5310
33.1	269	1635	108.5	883	5366
33.6	270	1631	110.1	887	5352

Table A-1. Boring RB-10VA, S - R1 quality assurance analysis P- and S_H-wave data

NEWBY ISLAND SANITARY LANDFILL BORING RB-12V

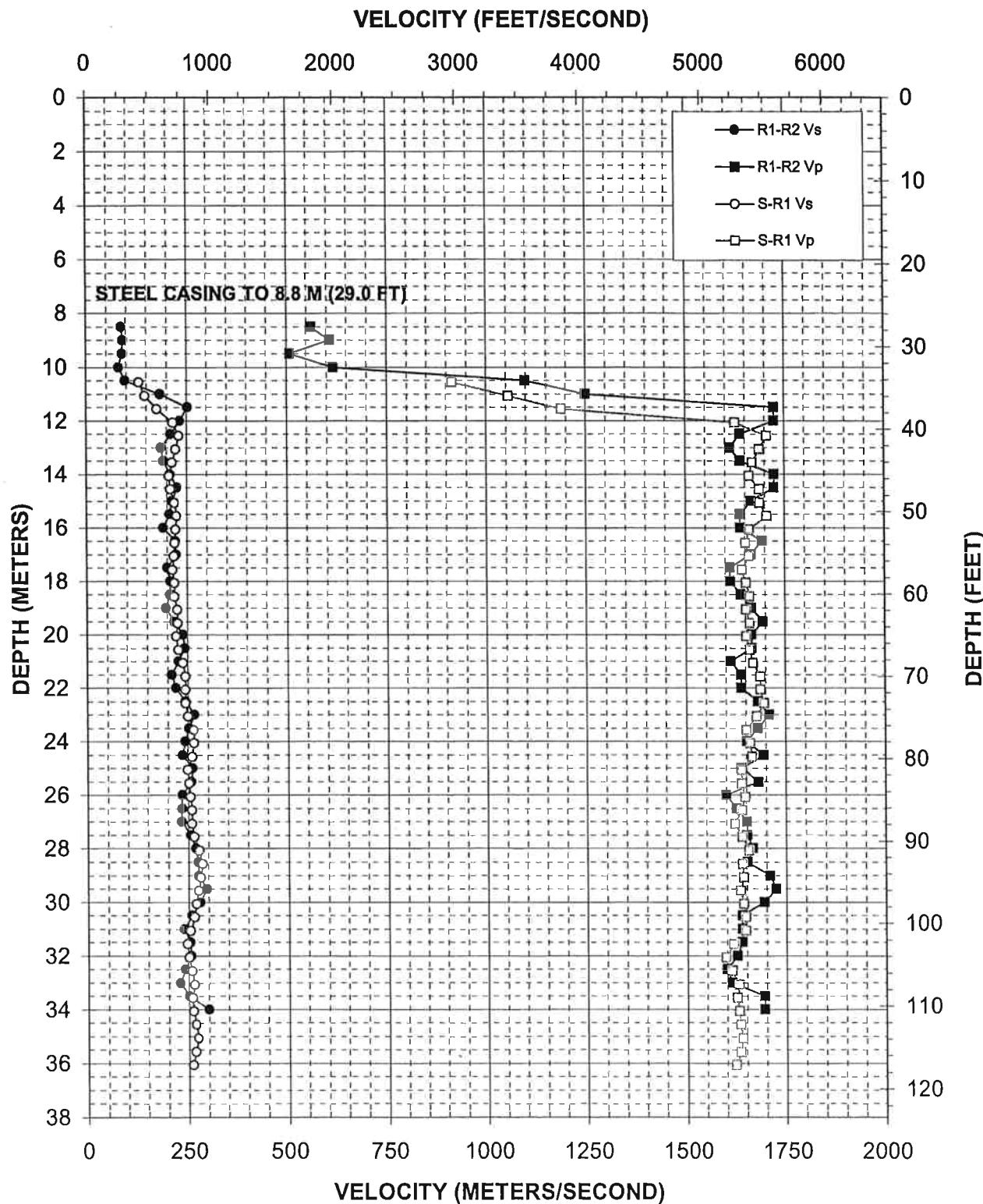


Figure A-2. Boring RB-12V, R1 - R2 high resolution analysis
and S-R1 quality assurance analysis

Depth (meters)	Velocity		Depth (feet)	Velocity	
	V-S _H (m/sec)	V-p (m/sec)		V- S _H (ft/sec)	V-p (ft/sec)
10.6	132	915	34.7	434	3003
11.1	146	1057	36.3	480	3469
11.6	176	1189	38.0	579	3902
12.1	216	1627	39.6	708	5338
12.6	231	1707	41.2	757	5599
13.1	222	1688	42.9	729	5539
13.6	214	1670	44.5	701	5480
14.1	205	1661	46.2	673	5451
14.6	209	1688	47.8	685	5539
15.1	219	1688	49.4	718	5539
15.6	224	1707	51.1	736	5599
16.1	221	1661	52.7	725	5451
16.6	219	1653	54.4	718	5422
17.1	217	1661	56.0	710	5451
17.6	213	1644	57.6	698	5394
18.1	218	1653	59.3	715	5422
18.6	218	1661	60.9	715	5451
19.1	224	1653	62.6	736	5422
19.6	226	1661	64.2	741	5451
20.1	221	1653	65.8	725	5422
20.6	228	1661	67.5	747	5451
21.1	238	1670	69.1	780	5480
21.6	244	1688	70.8	802	5539
22.1	244	1688	72.4	802	5539
22.6	244	1697	74.0	802	5569
23.1	249	1679	75.7	818	5509
23.6	265	1653	77.3	869	5422
24.1	265	1661	79.0	869	5451
24.6	261	1666	80.6	857	5465
25.1	248	1640	82.3	814	5380
25.6	252	1640	83.9	826	5380
26.1	255	1648	85.5	837	5408
26.6	259	1640	87.2	849	5380
27.1	259	1623	88.8	849	5324
27.6	265	1640	90.5	869	5380
28.1	277	1657	92.1	909	5436
28.6	286	1640	93.7	937	5380
29.1	282	1644	95.4	924	5394
29.6	276	1635	97.0	904	5366
30.1	269	1644	98.7	883	5394

Depth (meters)	Velocity		Depth (feet)	Velocity	
	V-S _H (m/sec)	V-p (m/sec)		V- S _H (ft/sec)	V-p (ft/sec)
30.6	264	1648	100.3	866	5408
31.1	254	1648	101.9	834	5408
31.6	246	1619	103.6	808	5310
32.1	251	1598	105.2	822	5243
32.6	259	1614	106.9	849	5297
33.1	265	1631	108.5	869	5352
33.6	260	1627	110.1	854	5338
34.1	261	1631	111.8	858	5352
34.6	268	1635	113.4	878	5366
35.1	273	1640	115.1	897	5380
35.6	266	1635	116.7	874	5366
36.1	260	1623	118.3	854	5324

Table A-2. Boring RB-12V, S - R1 quality assurance analysis P- and S_H-wave data

APPENDIX B

OYO 170 VELOCITY LOGGING SYSTEM NIST TRACEABLE CALIBRATION PROCEDURE

TABLE B1
GEOVISION VELOCITY LOGGING
EQUIPMENT DESCRIPTION AND
CALIBRATION PROCEDURES

EQUIPMENT	FUNCTION	CALIBRATION REQUIREMENTS	MAINTENANCE REQUIREMENTS
OYO Model 170 Suspension Logging Data Logger	Records data from probe and sends control signals to probe	Every twelve months, calibrate sample clock using an NTIS-traceable external signal counter and signal generator per attached procedure. (see Attachment B2)	Diagnose and repair by manufacturer's authorized representative if sample clock is out of specification or instrument fails.
OYO Model 170 Suspension Logging Probe	Suspended in borehole to provide both seismic source and sense wave arrivals at two locations 1 meter apart	No sensor calibration is necessary, as amplitude is not important to the velocity measurement.	Repair as needed by manufacturer-trained personnel.
Winch System (several interchangeable models available)	The winch and cable suspend the probe in the borehole and connect it to the data logger	No calibration required	Repair as needed. Lubricate moving parts frequently, and keep cable clean.

ATTACHMENT B2

CALIBRATION PROCEDURE FOR GEOVISION'S VELOCITY LOGGING SYSTEM

1.0 OYO Model 170 Data Logger Unit

1.1 Purpose

The purpose of this calibration procedure is to verify that the sample clock of the OYO Model 170 is accurate to within 1%.

1.2 Calibration Frequency

The calibration described in this procedure shall be performed every twelve months minimum.

1.3 Test Equipment

- Function Generator, Krohn Hite 5400B or equivalent
- Frequency Counter, HP 5315A or equivalent, current NIST traceable calibration
- Test cable, function generator to OYO 170 Data Logger input channels

1.4 Procedure

- Connect function generator to OYO Model 170 data logger using test cable
- Set up function generator to produce a 100.0 Hz, 0.250 volt peak square wave
- Record a data record with 100 microsecond sample period
- Measure the square wave frequency in the digital data using the data logger's screen display or utility software

1.5 Calibration Criteria

The measured square wave frequency in the digital data must fall between 99.0 and 101.0 Hz to be deemed acceptable. If outside this range, the data logger must be repaired and retested.



Calibration Report

11562 Knott Avenue, Suite 3, Garden Grove, CA 92841
Ph: (714) 901-5659 Fax: (714) 901-5649

Customer: **GeoVision, Corona, CA 92882**

Account: **15214**

Instrument: **BG9698 Suspension Logger**

Mfg: **OYO Geospace** Model: **03331-0000** Serial #: **15014**

Size: Resln: Cust Ctrl:

P.O.: Dept.: Location:

Report Date: **04/15/2005** Report #: **Tmp0003** Job #: **L23242**

Work Performed: **Inspected, cleaned, and calibrated.**

Parts Replaced:

Received Condition: **In tolerance**

Returned Condition: **In tolerance**

Functions Tested:

Frequency @ 100Hz

Square Wave Pass Unless otherwise noted

Sine Wave Pass Pass/Fail Criteria is

Based on published

Mfr. tolerances

See attached data

Control	Standard Used	Instr. Model	Due Date	NIST Trace Ref
AG2886	Frequency Synthesizer	3325A	10/12/2005	T1700

Environmental:	71 Deg F / 40% Rh	Test Date:	04/11/2005
Uncertainty:	<4:1	Cycle:	12
Cal Procedure:	Cust. Supplied	Due Date:	04/11/2006
Technician:	Jim Williams	Quality Approval:	





SEISMOGRAPH CALIBRATION DATA SHEET REV 7/11/02

INSTRUMENT DATA

SYSTEM MFR:	040	MODEL NO.:	3331
SERIAL NO.:	15014	CALIBRATION DATE:	4/11/05
BY:	<u>microprecision cal.</u>	DUE DATE:	4/11/06
COUNTER MFR:	TENMA	MODEL NO.:	72-5085
SERIAL NO.:	M600006378	CALIBRATION DATE:	4/8/05
BY:	<u>microprecision cal.</u>	DUE DATE:	4/8/06
FCTN GEN MFR:	HP	MODEL NO.:	2325A
SERIAL NO.:	1748A18000	CALIBRATION DATE:	10/12/04
BY:	<u>microprecision cal.</u>	DUE DATE:	10/12/05

SYSTEM SETTINGS:

GAIN:	10
FILTER:	20 kHz
RANGE:	100 mSec
DELAY:	0 mSec
STACK: 1 (STD)	1
PULSE:	1.6 mSec
DISPLAY:	VARIABLE
SYSTEM: DATE = CORRECT DATE & TIME	4/11/05 1:14 pm

PROCEDURE:

SET FREQUENCY TO 100.0HZ SQUAREWAVE WITH AMPLITUDE APPROXIMATELY 0.25 VOLT PEAK. RECORD BOTH ON DISKETTE AND PAPER TAPE. ANALYZE AND PRINT WAVEFORMS FROM ANALYSIS UTILITY. ATTACH PAPER COPIES OF PRINTOUT AND PAPER TAPES TO THIS FORM. AVERAGE FREQUENCY MUST BE BETWEEN 99.0 AND 101.0 Hz.

AS FOUND

100.0

AS LEFT

100.0

WAVEFORM	FILE NO	FREQUENCY	TIME FOR 9 CYCLES Hn	TIME FOR 9 CYCLES Hr	TIME FOR 9 CYCLES V	AVERAGE FREQ.
SQUARE	101	100.0	90.0	90.0	90.0	100.0
Square	102	100.0	90.0	90.0	90.0	100.0
SINE	103	100.0	90.1	90.0	90.0	100.0
SINE	104	100.0	90.0	90.0	90.1	100.0

CALIBRATED BY:

Jim Williams 4/11/05 J.W. Williams
 NAME DATE SIGNATURE